Respiration

Lecture 1

The functional structure of the respiratory system

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ILOs

By end of this lecture, (ISA) you should be able to:

- List the primary function of the respiratory system
- List the types of respiration
- Discuss the events of respiration
- Describe the functional structure of the respiratory system
- List the non-respiratory functions of the lungs
- Describe the respiratory protective mechanisms

Respiration, as the term is generally used, refers to the processes involved in the supply of the tissues with O_2 as well as the elimination of CO_2.

It includes two processes*:*

1- External respiration: Refers to the uptake of O_2 and removal of CO_2 from the body as a whole.

2- Internal respiration: Refers to the utilization of O_2 and production of CO_2 by cells and the gaseous exchanges between the cells and their fluid medium.

The respiratory system has

A. Respiratory function. B. Non-respiratory functions.

A. Respiratory function

This is the uptake of O_2 from the surrounding atmosphere and the elimination of Co_2 to it.

Events of Respiration (stages of respiration):

1- External respiration (pulmonary respiration): uptake of O_2 and excretion of CO_2 in the lungs

a- Pulmonary ventilation “breathing” Inhalation and exhalation &

b- Pulmonary gas exchange "within the lungs" diffusion of O_2 from alveolar air into pulmonary capillaries and diffusion of CO_2 from pulmonary capillaries into the alveolar air.

2- Transport of respiratory gases: transport of O_2 & CO_2 "via the bloodstream" O_2 from the lungs to the tissues & CO_2 from the tissues to the lungs

3-Internal respiration: "in the tissues" gas exchange between the tissue cells and their fluid medium & the utilization of O_2 and production of CO_2 by cells.

Normal respiratory rate at different age:

Newborn: 30 to 60/minute. Early childhood: 20 to 40/minute

Late childhood: 15 to 25/minute. Adult: 12 to 16/minute.

Phases of respiration: It occurs in two phases:

1. Inspiration during which air enters the lungs from atmosphere.

2. Expiration during which air leaves the lungs.

N.B.:

- The respiratory cycle is formed of inspiration, expiration and expiratory pause.
- During normal breathing, inspiration is an active process and expiration is a passive process.

Respiratory System is structurally divided into:

- *Upper respiratory system* includes 'nose, pharynx, larynx and associated structures'.
- *Lower respiratory system* includes 'trachea, bronchi and lungs'.

& it is functionally divided into:

- *Conducting zone*, conducts air to lungs, includes 'nose, pharynx, larynx, trachea, bronchi, bronchioles and terminal bronchioles'.
- *Respiratory zone,* main site of gas exchange, includes 'respiratory bronchioles, alveolar ducts, alveolar sacs, and alveoli'.

N.B.: Respiratory system does not accomplish all the steps in respiration. It is involved with the ventilation and the exchange of gases between the alveoli and blood. The rest of the respiratory processes are carried out by the circulatory system.

FUNCTIONAL ANATOMY OF RESPIRATORY TRACT

Respiratory tract is the anatomical structure through which air moves in and out. It includes nose, pharynx, larynx, trachea, bronchi and lungs.

Lungs: Highly elastic and distensible. Occupy most of the chest cavity. Each lung supplied by one of the bronchi. Each lung divided into several lobes. Separated from thoracic wall by the pleural sac

Pleura: Each lung is enclosed by a bilayer serous membrane called pleura or pleural sac.

Pleura has two layers (inner visceral attached firmly to the surface of the lungs and outer parietal layer which is attached to the wall of thoracic cavity).They are continuous at the hilum.

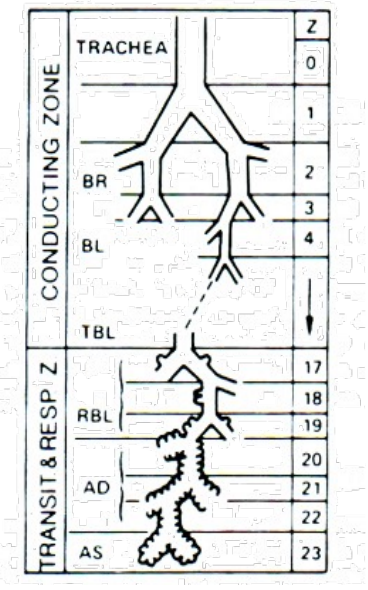
Intrapleural Space or Pleural Cavity: It is the narrow space in between the two layers of pleura.

It contains a thin film of serous fluid called intrapleural fluid, which is secreted by the visceral layer of the pleura. It is important in:

1. It functions as the lubricant to prevent friction between two layers of pleura
2. It is involved in creating the negative pressure called intrapleural pressure within the intrapleural space.

Tracheobronchial Tree (Trachea and bronchi), It forms a part of air passage.

Between the trachea and the alveolar sacs, the airways divide 23 times. *The first 16 generations* of passages form the conducting zone of the airways that transports gas from and to the exterior. *The remaining*



seven generations form the transitional and respiratory zones where gas exchange occurs

Importance of divisions 1-Greatly increase the total cross-sectional area of the air ways, from 2.5 cm^2 in the trachea to 11,800 cm^2 in the alveoli.

2- The velocity of air flow in the small airways declines to very low values…….

1. Trachea bifurcates into two main or primary bronchi called right and left bronchi
2. Each primary bronchus enters the lungs and divides into secondary bronchi
3. Secondary bronchi divide into tertiary bronchi. In right lung, there are 10 tertiary bronchi and in left lung, there are eight tertiary bronchi
4. Tertiary bronchi divide several times with reduction in length and diameter into many generations of bronchioles
5. When the diameter of bronchiole becomes 1 mm or less, it is called terminal bronchiole
6. Terminal bronchiole continues or divides into respiratory bronchioles, which have a diameter of 0.5 mm.

N.B.: The trachea and larger bronchi are fairly rigid, non-muscular tubes encircled by cartilaginous rings that prevent the tubes from being compressed. The smaller bronchioles have no cartilage to hold them open.

Exchange of gases occurs only in the respiratory unit “the structural and functional unit of lung".

Respiratory unit starts from the respiratory bronchioles.

Each respiratory bronchiole divides into alveolar ducts.

Each alveolar duct enters an enlarged structure called the alveolar sac.

Space inside the alveolar sac is called antrum.

Alveolar sac consists of a cluster of alveoli.

Few alveoli are present in the wall of alveolar duct also.

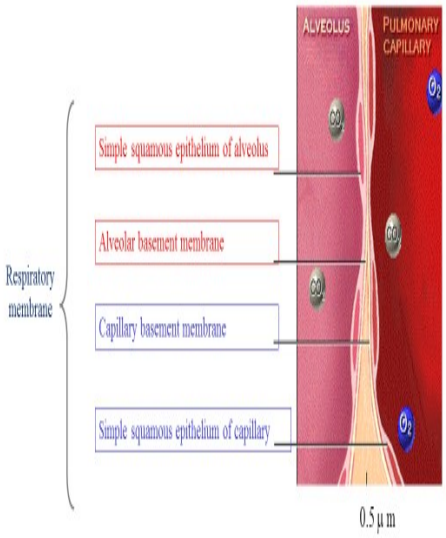
The respiratory unit includes:

1. Respiratory bronchioles 2. Alveolar ducts

3. Alveolar sacs 4. Antrum 5. Alveoli.

Each alveolus is like a pouch ‘air sac’ with the diameter of about 0.2 to 0.5 mm. It is lined by epithelial cells ‘single layer. Honeycomb-like clusters ~ 300 million. Large surface area.

Respiratory membrane ‘Alveolar – capillary membrane’ is the membranous structure through which the exchange of gases takes place.



- It separates air in the alveoli from the blood in capillary.
- It is formed by alveolar wall ‘type I, type II alveolar cells and alveolar epithelial basement membrane + capillary basement membrane + capillary endothelium.
- It is very thin, only 0.5 µm thickness, to allow rapid diffusion of gases.
- It has a surface area of 70 square meter.

N.B.: Alveolar Cells or Pneumocytes are of two types: 1- Type I alveolar cells (form the site of gaseous exchange between the alveolus and blood) 2- Type II alveolar cells (secrete alveolar fluid and surfactant). Other specialized cells are present in the alveoli e.g. …. .

B. Non-respiratory functions of the respiratory system

1. **Olfaction:** The mucous membrane of nostril contains the olfactory receptors responsible for olfactory sensation.

2. Vocalization or phonation "sound production": The speech apparatus includes the larynx with other structures. Larynx is called sound box "It plays a major role in the process of vocalization".

3. Prevention of dust particles

Dust particles, *which enter* the nostrils from air, are prevented from reaching the lungs by filtration action of the hairs in nasal mucous membrane.

Small particles, *which escape* the hairs, are held by the mucus secreted by nasal mucous membrane.

Dust particles, *which escape* nasal hairs and nasal mucous membrane, are removed by the phagocytic action of macrophages in the alveoli.

Particles, *which escape* the protective mechanisms in nose and alveoli are thrown out by cough reflex and sneezing reflex.

4. Defense mechanism: Lungs play important role in the immunological defense system of the body.

Defense functions of the lungs are performed by their own defenses and by the presence of various types of cells in mucous membrane lining the alveoli of lungs.

These cells are leukocytes, macrophages, mast cells, natural killer cells and dendritic cells.

i. Lung's Own Defenses: Epithelial cells lining the air passage secrete antimicrobial peptides such as Defensins "lung's natural defenses".

ii. Defense through Leukocytes 'against bacteria and viruses'.

iii. Defense through Macrophages 'engulf the dust particles and the pathogens'.

iv. Defense through Mast Cell 'produces the hypersensitivity reactions'.

v. Defense through Natural Killer Cell 'contain hydrolytic enzymes'.

vi. Defense through Dendritic cells 'function as antigen presenting cells'.

5. Maintenance "Regulation" of water balance 'water loss mechanism'. During expiration, water evaporates through the expired air 'body water is lost'.

6. Regulation of heat balance "body temperature" 'heat loss mechanism' during expiration, along with water, heat is also lost.

7. Regulation of acid-base balance: HOW? By regulating the carbon dioxide content in blood.

8. Anticoagulant function: Mast cells in lungs secrete heparin which is an anticoagulant and prevents the intravascular clotting. Also, the lungs contain fibrinolytic system. Moreover, the venous blood is filtered in pulmonary capillaries.

9. Metabolic and endocrinal functions such as

* *Secretion of angiotensin- converting enzyme*. Endothelial cells of the pulmonary capillaries secrete the angiotensin converting enzyme (ACE) which converts the angiotensin I into active angiotensin II It plays an important role in the regulation of ECF volume and blood pressure.

* Secretion of surfactant by type II alveolar epithelial cells.

* Synthesis of many substances and partial removal of others such as prostaglandins, serotonin...

10. Warming and humidification of inspired air.

11- Affect "help" the venous return and lymph flow through the breathing movement (inspiration and expiration).

12- Excretion of many volatile waste products e.g. acetone,

RESPIRATORY PROTECTIVE REFLEXES

Sneezing reflex

Cough reflex

	Sneezing reflex	**Cough reflex**
Definition:	It is a protective reflex caused by irritation of nasal mucous membrane. It is a modified respiratory process characterized by forced expiration.	It is a protective reflex and it is caused by irritation of respiratory tract, some other areas and also produced by several disorders.
Reflex pathway:		
Stimulus:	Irritation of the nasal mucous membrane.	Irritation of respiratory tract, some other areas
Receptors:	The olfactory receptors	Situated in several

	and trigeminal nerve endings present in the nasal mucosa.	locations such as larynx, pharynx, trachea, bronchi,…, ……..
Afferent nerve fibers:	Pass through the trigeminal and olfactory nerves.	Pass via vagus,.., glossopharyngeal and phrenic nerves.
Center:	Sneezing center is in medulla oblongata.	Center for cough reflex is in the medulla oblongata.
Efferent nerve fibers:	From the medullary center pass via trigeminal, facial, glossopharyngeal, vagus and intercostal nerves.	Arising from the medullary center pass through the vagus, phrenic and spinal motor nerves.
Effector organs:	The pharyngeal, tracheal and respiratory muscles.	The primary and accessory respiratory muscles.
Response:	Deep inspiration, followed by forceful expiration with opened glottis resulting in expulsion of irritant agents out of respiratory tract.	Deep inspiration followed by forced expiration with closed glottisà increases the intra….. pressure à then, glottis opens suddenly with explosive outflow of air at a high velocityà expulsion of irritant substances out of the respiratory tract.
State of glottis	??	??